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Develop a Comprehensive Technical Training and Data Collection Program for Structural Welders and Fitters

Technical Proposal

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Final Report

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EXECUTIVE SUMMARY

Welding is one of the major craft areas in shipbuilding and there is a need for continuous improvement in this area. However as senior welders retire, less experienced welders are not acquiring the in-depth knowledge from their mentors. In addition, foremen are challenged every day to properly assign all the work to the available craftsmen in an efficient and effective manner.

This project offers several innovations to improve welding productivity and quality. First a productivity measure based on the actual welds completed compared to the expected amount is introduced. The expected amount is computed using the rates appropriate for the location and type of weld combined with the joint data for the welded part. Second a well established quality metric, First Time Weld Quality, is incorporated into the system, thus providing measures of both quality and productivity at the individual level. Third the system is hosted on a handheld unit which provides the foremen with an efficient daily planning tool.

The Pilot System which entails developing and initiating a tool that has never been used in a shipbuilding environment was designed and shows extreme promise. However due to Hurricane Katrina, software problems, and production schedule conflicts the pilot system was not tested adequately enough to recommend wide spread adoption without further piloting. The conclusion and recommendation sections provide specific suggestions.

INTRODUCTION

Shipbuilders face a difficult challenge as the work force ages and manufacturing jobs are seen as less desirable; highly technical skilled structural welders become more difficult to find and retain. Fewer skilled tradesmen pass on "tribal-knowledge", the in-depth know-how acquired through years of experience that makes good welders great. As a result, the information associated with quality standards and dimensional tolerances almost completely passes to craft management and internal inspection agencies. The result is an over reliance on inspection to insure proper quality, often at the cost of multiple repair cycles.

A second issue relating to productivity involves daily planning accomplished by frontline supervision. Currently the frontline foreman establishes a daily work plan by evaluating what needs to be done considering available workers, equipment, materials and other factors. Experienced foremen do a reasonable job of juggling the many variables involved in this planning process. However, the work sequence and job assignments are often sub-optimum because of the complexity of the task and the pressures of time. In addition, limited information aids are available to assist in detailed daily tasking. The task then becomes highly subjective.

Pilot studies suggest that as much as 1/3 of productivity is lost due to these two concurrent issues.

This project has developed a comprehensive system which allows quality performance training, quality performance tracking, daily tasking, and daily status assessing for individual welders.

In addition detailed product data is available to production management in a paperless environment, which facilitates quantitative incremental tasking for production personnel. The system provides quality and performance metrics that may then be managed by supervision using wireless technology.

As shown in Figure 1, a wireless unit is the key element of the present system. Product data regarding weld joints is downloaded to the computer. Welding supervision uses product data to task the welders. At the end of the shift, the work completed is measured and entered into the handheld unit. Also one of the welder's co-workers will review the quality of the welds and enter the information into the handheld unit.

This data is used at the individual level to guide training in both quality and productivity. It is also summarized to provide shipyard management with a broad view of opportunities for improvement.

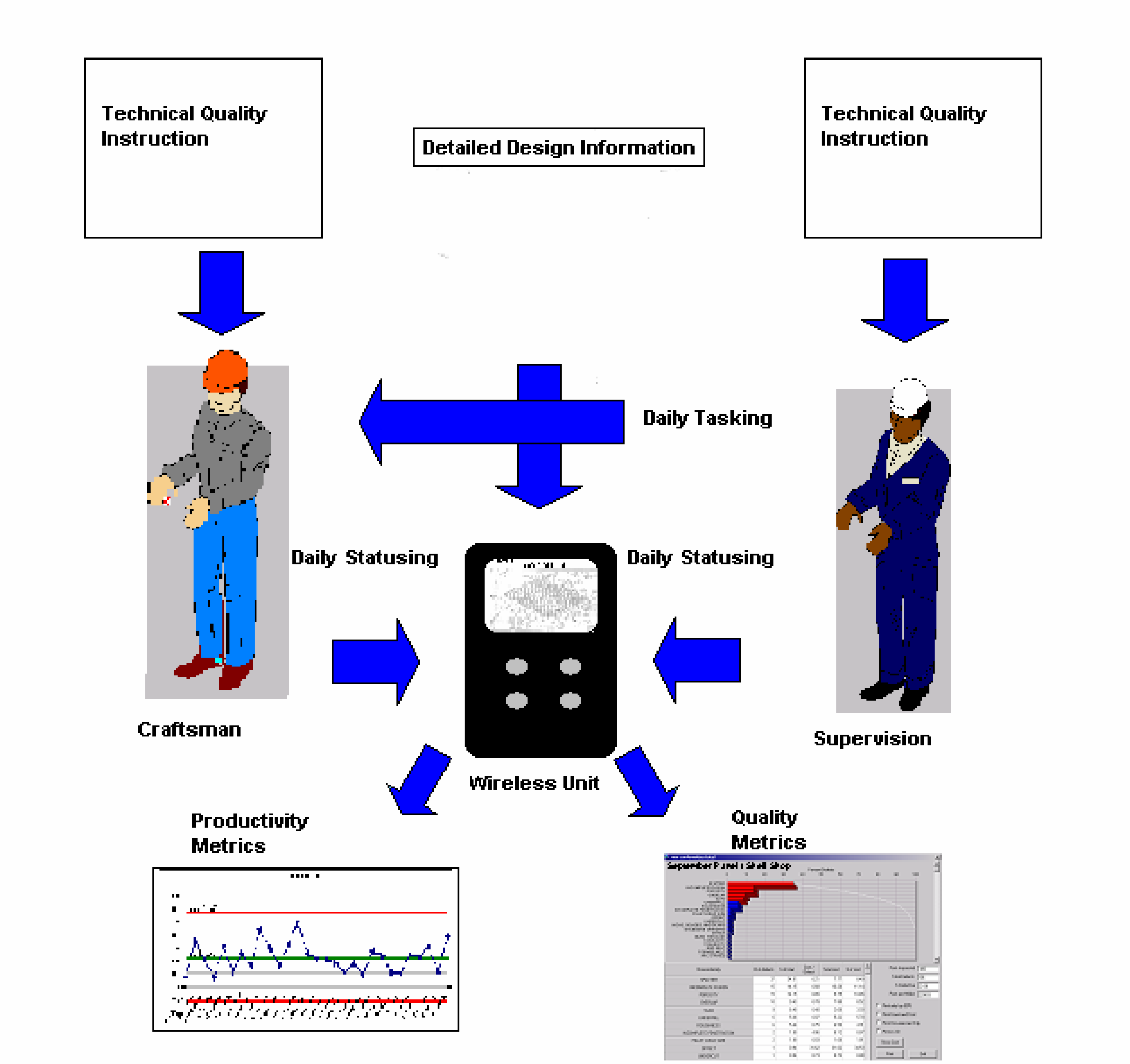

Figure 1: System Overview

The project is comprised of 6 tasks, including development of the process architecture, training of craftsmen and management, pilot phase study and project implementation.

Task 1: Initiate the Project Management System

- Develop meeting and review schedules and GANTT charts

Task 2: Develop Process Architecture

- Develop the Process Architecture that will provide the inputs and outputs of the decision support tool

Task 3: Develop and Test the Training Program

- Develop the training program focused on Visual Testing, Statistical Process Control and in-process data collection and output metrics for validation and ranking.

Task 4: Develop the user-interface for handheld data collection

- Purchase the handheld data collection tool and develop the user interface for data collection and the transfer method to legacy systems for metrics tracking.

Task 5: Pilot the System

- Implement the system in the identified pilot areas and generate metrics for validation and improvement

Task 6: Report Results

- Create final report capturing results of pilot and lessons learned to be captured in enterprise wide implementation

TECHNICAL PLAN AND RESULTS

Task 1: Initiate the Project Management System

Two senior NGSS production management personnel were named to manage this project: Donny Dorsey at Avondale Operations and Charles LaRue at Pascagoula Operations. Project meetings were held frequently at alternating sites to build a detailed understanding of both the quality and productivity sides of the project.

Quarterly Reviews were held with CNST personnel or a regular basis. The deliverables listed below were provided in a timely manner.

Deliverables
Process Architecture Document
Training Plan
System Design Plan
Pilot Program Plan
Final Report

Hurricane Katrina had a major impact on the project schedule, causing the end date to move about six months from the original plan. In addition uncertainty in production schedules adversely affected the project as the location of the pilot project shifted between the Avondale and Pascagoula sites.

In spite of these challenges, the team has developed and tested the planned system. The project results are discussed below.

Task 2: Develop Process Architecture

Goal

The Goal of this project is to develop a "report card" for individual welders addressing quality and productivity. In addition to the individual report shown in Figure 2, the data is aggregated to provide summary reports to management.

While the main goal of the project is to produce the welder report card, there are other equally important aspects of this project that are of great value. Some of these include:

- Scoping Databases which hold welding information for each piece produced in the pilot area
- Interfaces with statistical software to track productivity and quality providing metrics for management in real time
- The reduction or in some instances the elimination of paperwork allowing supervision to be more hands on

- Providing more interaction with the craftsman regarding his/her own work or the work of his/her peers

Report Card

Badge 1234 **Name** Sally Welder **Period** June

Quality Score: 87% **Productivity Score:** 78%

Comments: Excessive Spatter

Prior Period May

Quality Score: 85% **Productivity Score:** 70%

Figure 2: Report Card Concept

This system has been implemented in a pilot program using hand held computers in the web line and panel lines at Avondale and Pascagoula. The goal is to implement it at all NGSS locations.

Functional Decomposition

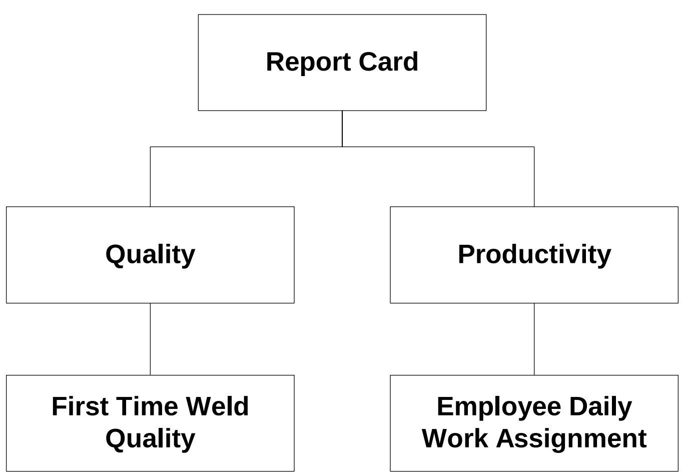

Figure 3: Functional Decomposition

The First Time Weld Quality System is currently implemented sector wide. Craftspeople have been trained in the key technologies as shown in Figure 4. Data is collected and reports are prepared using the DataLyzer™ system, a statistical package coupled to an Access database.

Topic	Welders	Fitters	Foremen	Mentors
Visual Testing Level 2	Y	N	Y	Y
Statistical Process Control	Y	Y	Y	Y
Data Collection	Y	Y	Y	Y

Figure 4: First Time Weld Quality Training

Defects are measured in defects per foot and categorized: spatter, overlap, incomplete fusion, slag, excessive grinding, incomplete penetration, underfill, weld reinforcement, crack, burn through, fillet weld size, concavity, convexity, undercut, end melt, corner melt, arc strikes, nicks, gouges, scars and porosity. The quality score is derived by dividing defects per foot by total opportunities. This data is entered into the First Time Weld Quality database.

The Employee Daily Work Assignment (EDWAS) sheet existed but it needed to be updated for this project. This project developed a system for creating assignments as well as data collection and analysis.

Creating Assignments

1. Determine the length of each joint in the unit to be welded. This would come from the drawings or a manual system.
2. Sort the joints based on process (FCAW, SMAW, etc), position (down hand, vertical up, etc) and weld size. Select the established rate for that joint.
3. Assign each welder enough joints for the shift.
4. Measure the hours worked and actual footage for each assigned weld.
5. Productivity is actual footage divided by assigned footage.

The EDWAS forms will initially be completed manually and the EDWAS data will be entered into the Productivity Database. Subsequently, for the pilot project, handheld units will be used for the preparation of EDWASs.

The results of the First Time Weld Quality system and the EDWAS Productivity system are combined to create the Welder Report Card.

Metrics for Success

This Pilot Project is being implemented in the web lines and panel lines. The value of this system will be quantified by comparing the labor hours with the system to labor hours without the system. For a particular panel design, it is possible to find duplicate or at least a similar panel that has been processed previously. After the Pilot Project is underway, we plan to compare the total welder and fitter labor hours for a completed panel using the EDWAS system with the hours for a similar panel completed prior to the EDWAS system. This comparison will be carried out for a number of panels. If a sustained reduction of 20% in welder and fitter labor hours can be achieved, then this is considered a success. In addition to this measure, the advancements made in the technology of assigning and tracking work also constitute a significant advancement and further qualify the project as successful.

Alternatives

Industry Practice

The Insight Report[1] provides a comprehensive review of welding productivity and quality. For major industries such as automotive, heavy industrial and aircraft, more than 70% of the total welding cost is associated with labor costs.

The study identified eight welding productivity measures:

- Welding speed (e.g. feet welded per period of time)
- Welding process output (e.g. joints completed per period of time)
- Welding deposition rate (e.g. pounds of weld metal deposited per period of time)
- Welding cell arc time (e.g. percentage time the welding cell is in operation)
- Welded product output – standardized product (e.g. welded components completed per period of time)
- Welded product output – customized product (e.g. tons of steel joined per period of time)
- Welding defect rate (e.g. defects per 100 welds completed)
- Performance versus time standard (e.g. percentage of production completed within a specified time standard)

Present Approach

With the present approach we have used two measures, one for productivity and one for quality. This addresses both dimensions of the problem. Also records are kept at the individual level which enables individual targeted training.

The weld quality measurement system, titled "First Time Weld Quality" is already in place and no alternative quality measurement systems were explored. This system will be integrated with the productivity system including changing the input to a handheld device rather than the current paper system.

As noted above, for the productivity system, the lengths for each joint must be established as part of the EDWAS. At the beginning of this project establishing the lengths of each joint was done manually using a tape measure. However a "scoping database" has been developed to aid in simplifying this effort. For this purpose, the drawing of each subassembly that will be processed under the pilot program was analyzed by operations personnel and the lengths of each joint were entered into the scoping database. Subsequently the scoping database has been linked to the EDWAS system. The lengths are directly available to the foreman.

In summary the present approach is an improvement over industry practice to measure productivity and quality at the individual level.

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[1] "Welding-Related Expenditures, Investments, and Productivity Measurement in the U.S. Manufacturing, Construction, and Mining Industries", Insight Management Advisory Services, May 2002

Employee Daily Work Assignment Sheet

The key to the productivity measure is a documented agreement between the foreman and the welder on the tasks to be done within the amount of time allocated for completion. This is accomplished through the Employee Daily Work Assignment Sheet (EDWAS) which contains the work assignment as well as other pertinent data. Figure 5 shows the top two thirds of the EDWAS.

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Employee's Daily Work Assignment Sheet

Employee's Name ________________ Badge # ________ Shift ______ Date ____________

Hull ______ Unit ________ Compartment ____________ Foreman's Name ________________

Job #/Work Authorization ________________

STOP! Is the work area safe	Yes ☐	No ☐	Employee wearing required PPE	Yes ☐	No ☐
Employee has a weld gauge	Yes ☐	No ☐	Employee has the temp sticks	Yes ☐	No ☐
Employee has correct drawing revision	Yes ☐	No ☐	Material to be fit or welded is properly identified type/grade	Yes ☐	No ☐
Weld size properly marked	Yes ☐	No ☐	Employee knows proper filler material to be used	Yes ☐	No ☐
Fire watch present where required	Yes ☐	No ☐			

Primary Job Assignments

Work area: Shop/Platen ☐ Unit Construction Area/Halls ☐

S/A	Weld Type	Position	Weld Size	# of Passes	Assigned Footage	Assigned Hours	Actual Footage	Actual Hours	Difficulty Level

Weld Type = Fillet or Butt
Position = Vertical, Overhead, or Flat/Down Hand

Difficulty Level is a value from 1 to 3 with 3 being the hardest

Figure 5: Employee Daily Work Assignment Sheet

Another goal of the project is to complete this form via a handheld unit. However at the outset, the handheld was not available so it was decided to develop a prototype system using an Access database. The prototype was valuable in defining each of the steps to complete an EDWAS. However it was not practical for testing the system because of schedule and complexity.

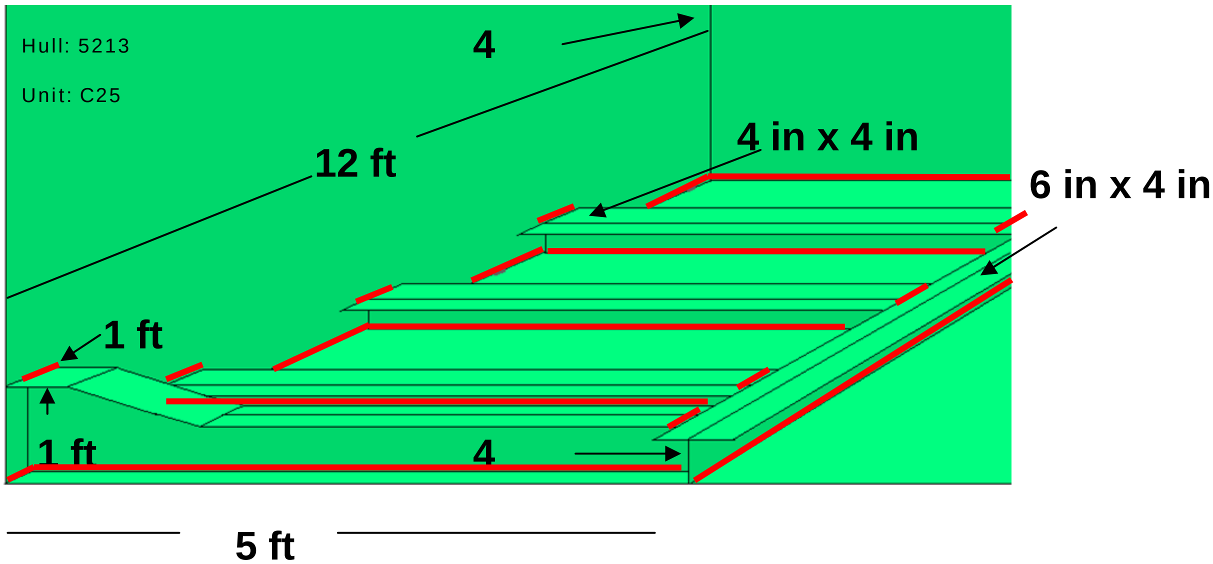

Figure 6: Subassembly to be Welded

The following example explains the steps that are required to complete the EDWAS via the prototype system. For a particular subassembly (S/A), such as shown in Figure 6, the foreman establishes the weld type, position, weld size, and number of passes, for example 3/8", fillet weld, FCAW, down hand. Based on drawings or tape measure, he determines there is 85 ft to be welded. The reference Weld Table shows that this weld should take 10 hours. This constitutes the welder's assignment for the day. At the end of the day, the actual length completed is measured. The ratio of the length completed to the length assigned is the measure of productivity.

Task 3: Develop and Test the Training Program

The purpose of the training program is to provide the foremen and other production people with the knowledge necessary to make this project successful as well as to obtain feedback to enhance the program. Because the First Time Weld Quality system is already in operation, the focus of the training is on the Employee Daily Work Assignment System.

At the beginning of the project, the Project Team and Senior Production Management met with the foremen in the Pilot Group. The purpose and scope of the project was explained and the Senior Management emphasized the importance of the new system.

The EDWAS requires that, for a particular weld of a certain length, the estimated time must be provided. Three alternative methods were identified: look the time up in a table or calculate the time either by dividing by the rate or multiplying by a factor (equal to the inverse of the rate.) The Project Team consulted the Pilot Group and the consensus was to use the table method.

The first training session was carried out after the EDWAS was finalized and the associated database input screen was coded. This was a joint training session for both Pascagoula and Avondale personnel and it was taught by two project team members. The Training Department supported this session.

The foremen are responsible for entering the daily assignment data using a paper form. The students were given a paper EDWAS form, the Weld Time Table and a copy of the slides. The training addressed each section of the EDWAS with special emphasis on the assignments section. The foremen were coached on establishing the weld conditions, length and time. The questions from the two sites provided a good interchange.

Subsequently, when the handheld system was introduced, training was done on-the-job with a project team member working directly with the foreman to prepare the daily assignments.

The First Time Weld Quality input form is also on the hand held unit. The actual data input is done by the Mentors responsible for First Time Weld Quality. Training for these participants for the handheld system went very smoothly and there has been good acceptance.

After the decision is made to roll out the systems developed under this project, a similar training program will be required for other foremen throughout the yard. The materials developed here will be used to "train the trainers" and would most effectively be taught by the Training Department.

Task 4: Develop the user-interface for handheld data collection

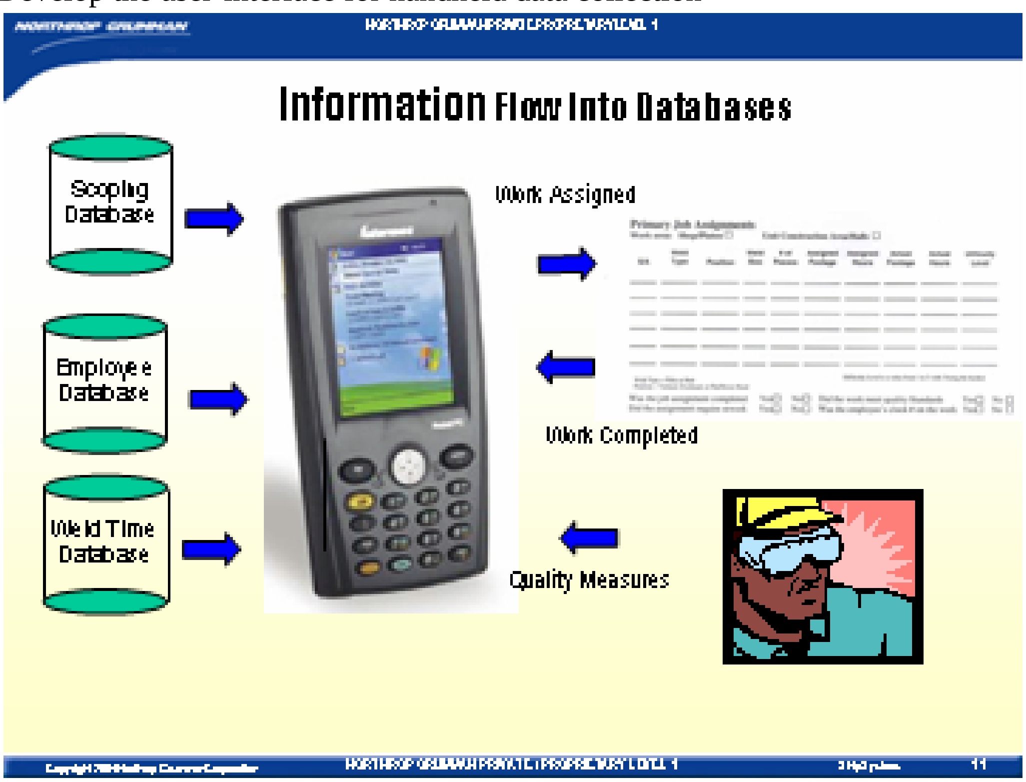

Figure 7: Information Flow into Databases

The handheld unit provides significant advantages over the prototype Access system. The employee information is built into the system as is the reference weld time database. The important new feature is the scoping database. This database contains all the information regarding welding lengths associated with each subassembly. It was constructed by doing manual take-offs of joint lengths from the manufacturing drawings. Figure 7 shows it is used to prepare the daily work assignment for individual welders as well as to record actual work completed. It is also used to record the weld quality data for the individual as shown in Figure 8.

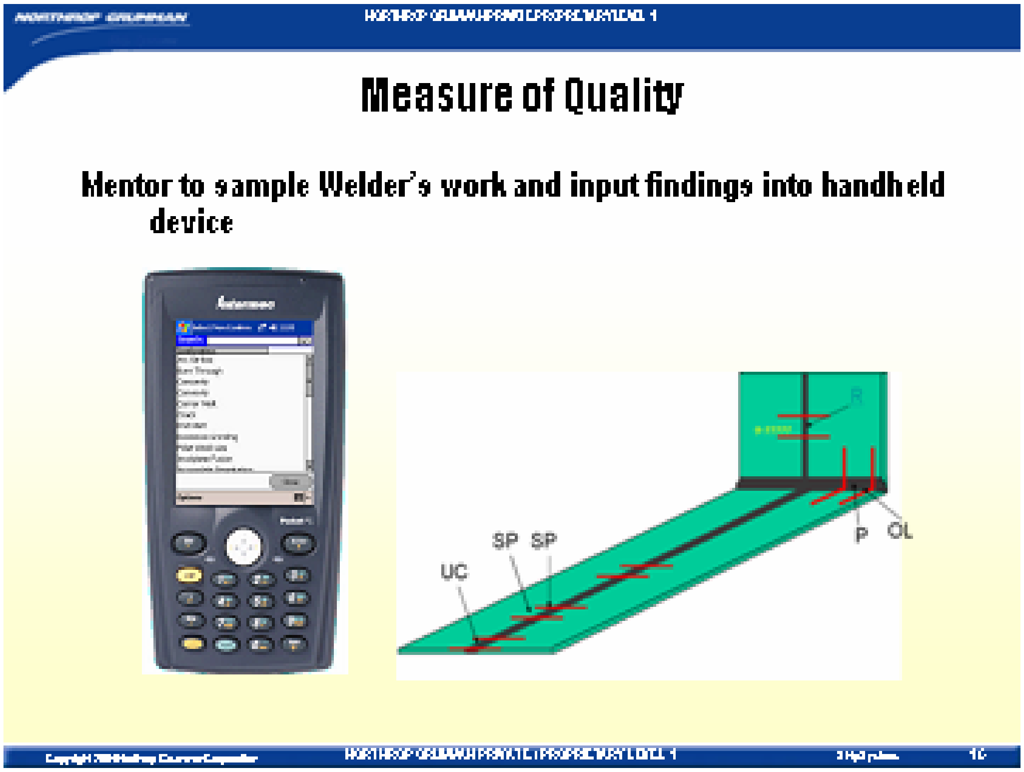

Figure 8: Measure of Quality

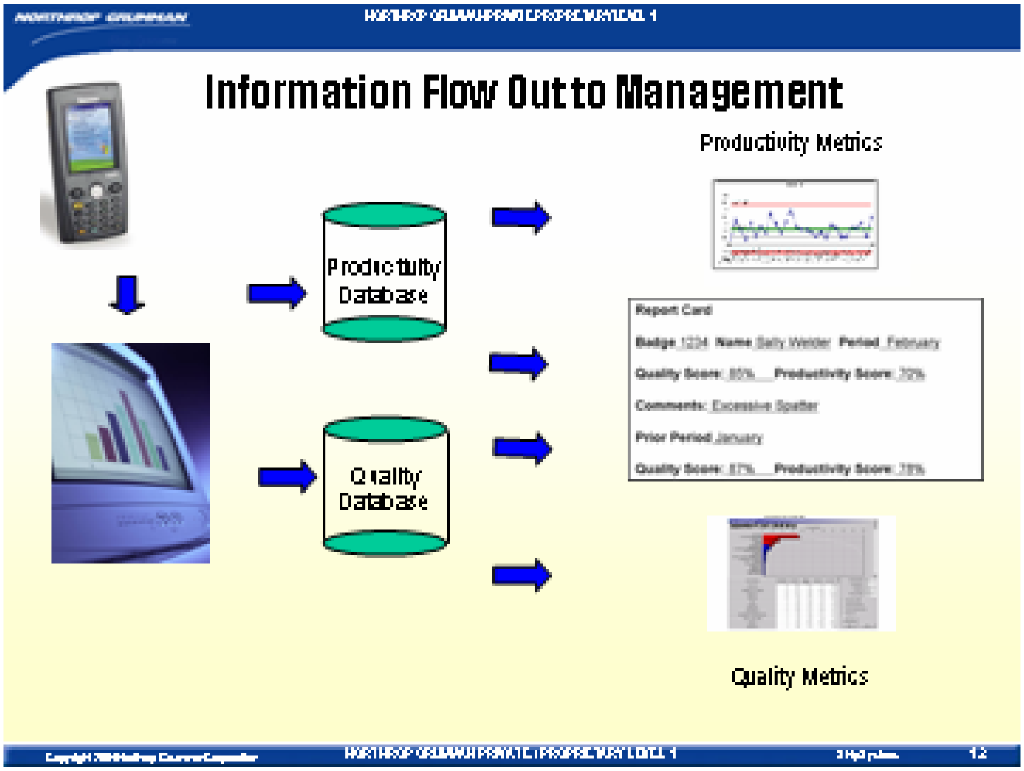

Figure 9: Information Flow out to Management

The data collected in the handheld is downloaded at every shift to a PC for further processing and reports to management.

Task 5: Pilot the System

The objectives of the Pilot Project were to:

- Demonstrate that the handheld system can be effectively used for production activities such as assigning daily tasks and collecting completion and quality data
- Quantify quality and productivity improvements in support of a business case for sector wide implementation.

A two month pilot was planned at the Avondale site. However because of the complexity of the software, a working system was not available until the last month of the project. This left us with insufficient time to get the system working smoothly. In addition to the software delay we ran into production schedule issues which lead us to abandon the EDWAS portion of the pilot project at Avondale and focus EDWAS entirely at the Pascagoula site. The software, handheld devices, and scoping database made this an easy transition. Yet our experience to date is not adequate to support the business case for rollout.

Training has been accomplished by having a project team member working directly with the craft personnel. There is good acceptance of the handheld as a useful tool for supporting production, particularly in the quality area. At first glance the foreman felt that the system required a larger amount of planning time compared to the current manual planning system. Current interviews with the foreman using the handheld device contradict this. Foremen did point out that being able to group repetitive jobs, such as water tight clips and collars would aid in speeding up the process even more.

There is some skepticism in the productivity area regarding uncommon aspects of production that were not accounted for which may adversely affect reported productivity. At this point in the project no such instances have occurred thus we are unable to confirm or deny this.

Task 6: Report Results

This is the final report for the project. The project team from both NGSS sites as well as NGIT, UNO and POSDATA worked together well to define and address the challenges of introducing the new system. The concept of measuring both productivity and quality is new for heavy industry; the use of handhelds is new for shipbuilding. We were over optimistic in believing a new system could be designed and fielded in one phase. However there is significant value in the present approach and it should not be abandoned.

CONCLUSIONS AND RECOMMENDATIONS

1. The concept of measuring Productivity and Quality is unique in Heavy Industry and provides significant value as a part of a program for continuing improvement. The Quality part is working well and has been enhanced by migrating to handheld units.

2. The scoping database is an important tool for work estimation on the shop floor. Creation of the database should be automated by extracting weld joint and other information directly from the product model.

3. Both the foreman and the welders recognize the value of appropriate work assignments and are comfortable with the efficiency of the handheld units. However refinements are needed to the work assignment process to recognize non-productivity activities and programmatically reduce them. Also weld times need to be validated as a part of agreement between the foreman and the welder on daily work assignments.

4. Items 2 and 3 are required to support an attractive business case for this concept.